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ORIGINAL RESEARCH

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Evaluation of accuracy of an electronic apex locator in presence of sodium hypochlorite in primary teeth with and without resorption

Gamze Topçuoğlu[1,*], Kevser Kolçakoğlu[2]

[1]Department of Pedodontics, Faculty of Dentistry, Haci Bektaş Veli University, 50040 Nevşehir, Turkey
[2]Department of Pedodontics, Faculty of Dentistry, Erciyes University, 38039 Kayseri, Turkey

***Correspondence**
gamzetopcuoglu@nevsehir.edu.tr
(Gamze TOPÇUOĞLU)

Abstract

This study compared the accuracy of Root ZX mini apex locator in presence of sodium hypochlorite (NaOCl) in primary molars with and without apical resorption. Sixty-four extracted primary lower molar teeth with 32 root resorption and 32 without resorption were selected. To determine the actual working length (AWL), a K-file was inserted into the root canal until the tip of the file was visible at the major foramen or the resolution level. It was then withdrawn 1 mm. This value was recorded as AWL. The teeth were then divided subgroups (with/without NaOCl). To determine the electronic working length, a Root ZX mini apex locator in canals with/without NaOCl was used. A K-file was inserted into the canal to just beyond the foramen, as indicated by the flashing "APEX" bar, and the electronic working length was determined by subtracting 1 mm from this length. The deviation of the Root ZX mini measurement from the AWL was determined. Student's *t*-test was used for statistical analysis. In teeth with no resorption, the measurement accuracy rates (within+/−0.5 mm) of non-NaOCl and NaOCl groups were 84.37% and 81.25%, respectively ($p > 0.05$); within+/−1 mm, the non-NaOCl and NaOCl demonstrated 100% and 96.87% accuracy, respectively ($p > 0.05$). In teeth with resorption, the measurement accuracy rates (within+/−0.5 mm) was 81.25% for the non-NaOCl and 62.50% for the NaOCl, respectively ($p < 0.05$). The measurement accuracy rates (within+/−1 mm) of the non-NaOCl and NaOCl was 96.87% and 84.37%, respectively ($p < 0.05$). The presence of NaOCl in the root canal affected the accuracy of the Root ZX mini in primary teeth with apical resorption, but not in teeth without resorption.

Keywords

Primary tooth; Resorption; Root canal treatment; Root ZX mini; Sodium hypochlorite

1. Introduction

Primary tooth root canal treatment includes removing infected root pulp tissue, mechanically shaping the root canals, purifying them of microorganisms and toxins with various irrigation methods, and filling them completely to the root apex with a resorbable filling material with antibacterial properties to prevent re-infection. It has been reported that there is a high success rate in studies on primary tooth root canal treatments [1].

Traditional radiographs are widely used in primary tooth treatments. However, the disadvantages of radiographs are that the correct reference points cannot always be determined due to anatomical variations, superpositions and distortions in two-dimensional radiographic images obtained with conventional radiography, and the patient's exposure to X-rays. It is reported that the use of an electronic apex locator (EAL) eliminates these disadvantages [2]. It is stated that EALs can produce beneficial results, especially when radiographic imaging of the root apex is prevented by certain anatomical structures such as bone density, superposed tooth roots or zygomatic arch [3]. Unlike radiographic methods, by using the EAL the patient is not exposed to radiation, and the elimination of the time required to take a traditional film image are indicated as important advantages in the use of an EAL [4].

The accurate determination of the working length (WL) in primary teeth is necessary to prevent damage to periradicular tissues, as well as to protect permanent tooth germs from possible infection. However, the special conditions of primary teeth make it difficult to determine the working length [5]. Researchers have stated that there are anatomical difficulties in root canal treatment in primary teeth. Unlike the tooth root morphology of permanent teeth, the canals of primary teeth have an inclined angle and the presence of permanent tooth germ under the primary tooth requires careful treatment [6, 7]. In addition, the fact that primary teeth do not have apical constriction due to the physiological root resorption and the constant change of the apical foramen due to physiological

resorption makes it difficult to determine the reference point at which the WL will be terminated in primary teeth [8]. It is also emphasized that despite the above-mentioned advantages of EALs, it is necessary to take into account a number of factors that limit their success [9]. It has been reported that factors such as metallic restorations, excess electrolytes, blood or exudate in the canal, caries, saliva, canal instruments in another canal, debris accumulation in the canal, and calcifications can negatively affect WL measurement [10]. Various studies have shown that pulp vitality, the presence of electrolyte in the canal, the degree of resorption, canal width, the diameter of the canal instrument, and differences in experience among practitioners can negatively affect the success of EALs [11–13].

Irrigation solutions help to increase the efficiency of mechanical shaping in endodontic treatment, by removing dentin and pulp residues, reducing microorganisms and controlling infection. Sodium hypochlorite (NaOCl) solution is a powerful antimicrobial agent and is widely used for the irrigation in primary teeth as well as in permanent teeth, as it is a good organic tissue solvent [14]. The aim of this study was to evaluate the accuracy of the Root ZX mini apex locator (J. Morita Co., Tokyo, Japan) in the presence of NaOCl in primary teeth with/without apical resorption. The null hypothesis was that the presence of resorption and NaOCl had no effect on the accuracy of Root ZX mini.

2. Materials and methods

Based on the data of Bodur *et al*. [15], it was determined that the sample size should be at least 32 for each group (power 0.80, effect size = 0.763 and significance level a = 0.05). Sixty-four primary first lower molar teeth extracted from children aged 4 to 6 years due to periapical pathology and preventive orthodontic treatment, were used. 32 of these teeth were with root resorption and 32 were without resorption. Two researchers determined the presence of root resorption independently. Prior to the experimental procedures, the teeth were examined under a dental microscope at 16-magnifications (OPMI Pico, Zeiss, Oberkochen, Germany) to detect any cracks or fractures. Specimens were stored in distilled water.

After preparing the endodontic access cavity of the teeth, the occlusal surface was smoothed to form a flat surface perpendicular to the long axis of the distal canal. In this study, only distal roots were used for WL measurement. To determine the actual working lengths (AWL), a #10 K-type file (Dentsply Sirona, Ballaigues, Switzerland) was inserted under a 16-magnification dental microscope until the tip was visible in the major apical foramen or at the level of apical resorption. The distance between the point where the stopper of the file touched the coronal surface and the tip of the file was measured with an electronic caliper with 0.01 mm precision. AWL was determined by subtracting 1 mm from this measurement. To measure the WL electronically, the teeth were embedded in an alginate model similar to an earlier experimental setup (Fig. 1) [16]. While measuring the electronic working length (EWL) in the NaOCl groups of resorption and non-resorption teeth, the measurements were performed following irrigation with 1% NaOCl. All measurements were performed by the same operator who did not know the resorption status of the teeth. For canal length determination with the ROOT ZX mini (J. Morita Co., Tokyo, Japan) apex locator, a #10 K-file was inserted within the root canal up to the point where the apex locator says "APEX", and measurements were considered to be valid if the reading remained stable for at least 5 s. The silicon stop of the file was adjusted and the file were fixed in place with cyanoacrylate. The distance from the file tip to the base of the rubber stop was measured with a caliper to the nearest 0.01 mm. EWL was determined by subtracting 1 mm from this length. All measurements were repeated three times and the average was recorded.

In each specimen, the AWL was subtracted from the EWL. Positive values indicated measurements exceeding the AWL, and negative values indicated measurements short of the AWL. The AWLs ±0.5 mm and ±1 mm were used to evaluate the accuracy of the Root ZX mini EAL. The EWL and AWL measurements were compared using the Student's *t*-test (SPSS 20.0; IBM Corp, Armonk, NY, USA). The kappa test was used to analyze intra-examiner agreement.

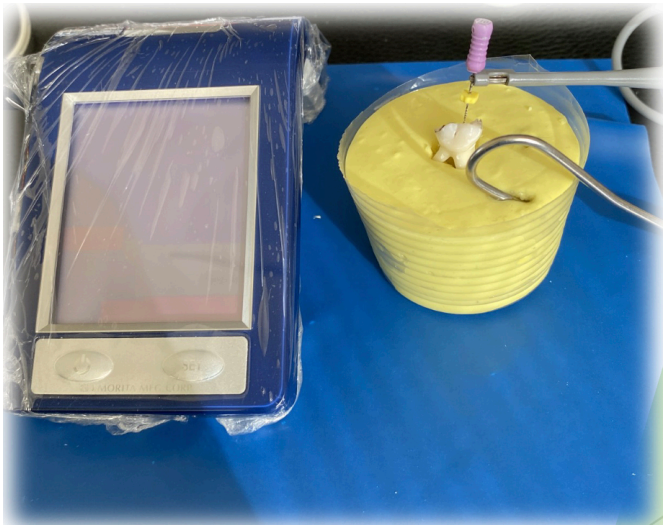

FIGURE 1. Experimental setup showing Root ZX mini apex locator connected to teeth.

3. Results

The kappa test showed that the intra-examiner agreement was 92.6%. Table 1 shows the Root ZX mini EAL measurements. For teeth with no resorption, the accuracy rates (within+/−0.5 mm) of the non-NaOCl and NaOCl groups were 84.37% and 81.25%, respectively ($p > 0.05$), while within+/−1 mm, the non-NaOCl and NaOCl demonstrated 100% and 96.87% accuracy, respectively ($p > 0.05$). For teeth with resorption, the accuracy rates of measurements within+/−0.5 mm was 81.25% for the non-NaOCl and 62.50% for the NaOCl, respectively ($p < 0.05$). The accuracy rates (within +/−1 mm) of the non-NaOCl and NaOCl was 96.87% and 84.37%, respectively ($p < 0.05$).

The mean differences between the EWL and the AWL values in millimetres are shown in Table 2. In the resorbed canals,

TABLE 1. The number of measurements that were within an acceptable range of ±0.5 and ±1 mm and those that were either short or long.

	Resorption		Non-resorption	
	Non-NaOCl	NaOCl	Non-NaOCl	NaOCl
<−1.0	0	2	0	1
(−1.0)–(−0.5)	2	2	3	4
(−0.5)–(0.0)	14	9	6	4
(0.0)–(0.5)	12	11	21	22
(0.5)–(1.0)	3	5	2	1
>1.0	1	3	0	0

NaOCl: sodium hypochlorite.

TABLE 2. Means and standard deviations between the values obtained with Root ZX mini electronic apex locator and the actual length (mm).

	NaOCl	Non-NaOCl	*p* value
Resorbed	0.14 ± 0.08^{a}	0.03 ± 0.02^{b}	0.042
Not resorbed	0.32 ± 0.14^{c}	0.28 ± 0.06^{c}	0.627

NaOCl: sodium hypochlorite. There was no statistical difference between groups having the same letters ($p > 0.05$).

the mean difference was 0.14 ± 0.08 mm for the NaOCl group and 0.03 ± 0.02 mm for the non-NaOCl group ($p < 0.05$). In the not resorbed canals, the mean difference was 0.32 ± 0.14 mm for the NaOCl group and 0.28 ± 0.06 mm for the non-NaOCl group ($p > 0.05$).

4. Discussion

The current study determined that EAL measurements in teeth without root resorption were not affected by the presence of NaOCl. On the other hand, NaOCl affected the measurement accuracy in teeth with resorption. Therefore, the null hypothesis was partially rejected. It has been stated that since primary tooth roots are usually obliquely resorbed in the buccolingual plane, it is not possible to determine the resorption level accurately with the use of radiographs. Therefore, even in cases where resorption progresses, this cannot be seen on the radiograph and the observed root length may be misleading [5].

In the current study, as in many previous studies [11, 15], an alginate model was preferred in order to evaluate the accuracy of the apex locator in the presence of different variables such as root resorption and NaOCl. Because of the physiological root resorption that occurs in primary teeth, the correct detection of the WL is of great importance. Therefore, clinically-acceptable error tolerance was stated to be ±0.5 mm or ±1 mm [17, 18]. In this study, the accuracy of the Root ZX mini EAL was evaluated using both ±0.5 and ±1 mm AWLs.

It has been stated that with low magnification, some difficulty can be experienced in visualizing the exact location of the tip of the file, especially in primary teeth with resorption [19]. Therefore, in order to control for this, all measurements were made under a ×16 magnification dental operating microscope. When the literature is reviewed, there appears to be no studies evaluating the accuracy of EALs in the presence of NaOCl in primary teeth. Therefore, this study focuses on this aspect. In a previous study, an EAL used in the presence of solutions with high electroconductivity such as NaOCl and saline solution, showed higher accuracy compared to the presence of chlorhexidine (CHX) and EDTA [20]. In studies with solutions with weak electroconductivity, EWL measurements were longer than those of AWLs. Venturi and Breschi [21] reported that the measurements made by EALs may be inconsistent or inaccurate when the conductor ratio in the root canal is low.

It has been reported in some studies that modern EALs can maintain their accuracy in the presence of irrigation solutions [22, 23]. Some authors argue that the presence of electrolyte solutions in the root canal is one of the most important factors affecting measurements made using EALs. Fan *et al.* [24] reported that electroconductive solutions significantly reduce the impedance in the canal, and may cause short measurements due to high electroconductivity.

NaOCl dissociates into sodium and chloride ions in the reaction involving the dissolving of organic tissues. Due to this dissociation, it was observed that NaOCl, which has high electroconductive properties, adversely affected the operating accuracy of the Propex apex locator during measurement [25]. Root ZX EAL, on the other hand, was found to give accurate results in terms of WL measurements under the influence of different NaOCl concentrations [25]. The measurement accuracy of Raypex 5 (VDV, Munich, Germany) and ApexDal (Septodont, Saint-Maur-des-Fossés, France) was compared with the gel and solution forms of CHX in the direction of the effect of 2% NaOCl, and it was found that the use of 2% NaOCl greatly affected the measurement accuracy of the Raypex 5 and ApexDal EAL [26].

Studies evaluating the accuracy of EALs in the presence of root canal irrigation solutions in permanent molars have produced varying findings. Some studies have determined that irrigation solutions do not affect the accuracy of EALs [22, 23],

while others have reported that irrigation solutions may cause short or long measurements [20, 25]. This is the first study to evaluate the accuracy of an EAL in resorption primary teeth in the presence of NaOCl. Therefore, the findings of this study can be compared with studies in which the accuracy of apex locators were evaluated in primary teeth with and without resorption. Tosun *et al*. [19] compared the accuracy of two EALs for measuring WL in primary teeth, with and without apical resorption. They found that the Root ZX was not affected by the presence of resorption, whereas the Tri Auto ZX was. Based on the findings of their study, Angwaravong and Panitvisai [27] stated that the accuracy of the Root ZX was high and not affected by root resorption. Similarly, in the present study, the presence or absence of resorption in NaOCl-free groups did not affect the measurement accuracy of the EAL, which is consistent with the findings of the aforementioned studies.

Despite the successful results with regard to EALs in resorbed primary teeth, Kim and Chandler [28] stated that in cases where the apical opening in primary teeth is large due to root resorption, EAL measurements should be confirmed by radiographic techniques, so that fewer adjustments need be made. It has been suggested that better measurements can be made using radiography. Kim *et al*. [29] stated that in teeth with 84% accuracy WL measurement using only EALs, the accuracy rate increased to 96% when these measurements were later supported by radiography. Similarly, Bodur *et al*. [15] also emphasized that it is necessary to use supportive methods in conjunction with EALs.

5. Conclusions

The accuracy of the Root ZX mini EAL in primary teeth with apical resorption affected from the presence of the NaOCl in the root canal, but not in teeth without resorption. More studies are needed involving different irrigation solutions and different types of apex locators on this issue.

AVAILABILITY OF DATA AND MATERIALS

The data presented in this study are available on reasonable request from the corresponding author.

AUTHOR CONTRIBUTIONS

GT—contributed to the study design, data collection, analysis and interpretation and drafted the manuscript. KK—contributed to the study design, analysis, interpretation and critical review of the manuscript.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

This study was approved by Nevşehir Hacı Bektaş Veli University Ethics Committee (2023/223). For this type of study, formal consent is not required.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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